Detached Melt and Vapor Growth of InI in SUBSA Hardware

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OVERVIEW

- **Introduction**
- **SUBSA furnace**
- **Wetting angle results for InI on different substrates**
- **Ampoule setups**
- **Conclusions**

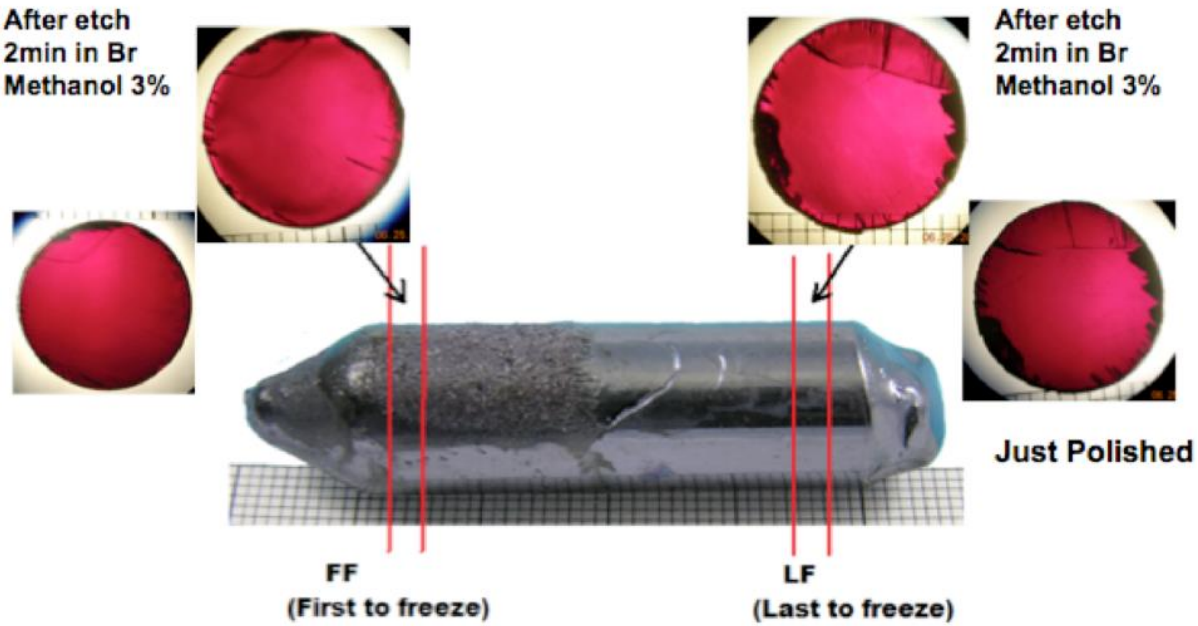
INTRODUCTION (I)

- **Monovalent Indium Iodide, InI, is a promising candidate for γ-ray and X-ray detectors**

Material	$Cd_{0.9}Zn_{0.1}Te$ (CZT)	HgI_2	InI
Average atomic number, Z	49.1	62	51
Density, g/cm^3	5.78	6.4	5.31
Band gap, eV	1.55	2.14	2.0
Melting point, ^oC	~1100	259	351
Structure	Zincblende	Tetrahedral-layered	Orthorhombic
Knoop Hardness, kg/mm^2	92	10	27
Molecule Disassoc. Energy eV Herzberg's tables [19]	1.2	0.35	3.43
Electrical Resistivity, Ohm-cm	3×10^{10}	10^{13} to 10^{14}	5×10^{11}

INTRODUCTION (II)

- The low melting point and congruent sublimation allow both melt growth and vapor growth.
- InI is not toxic and not hygroscopic



VB-grown crystal and wafers (IIT)

CZ-grown crystals (IIT)

INTRODUCTION (III)

- Current problems with InI are:
  - Purity of the starting material. IIT has developed considerable experience in purifying In and I, synthesizing InI from the elements, and further purifying InI by zone melting.
  - The formation of small inclusions in the grown material. These are thought to be responsible for the reduced electronic properties, compared to theoretical values

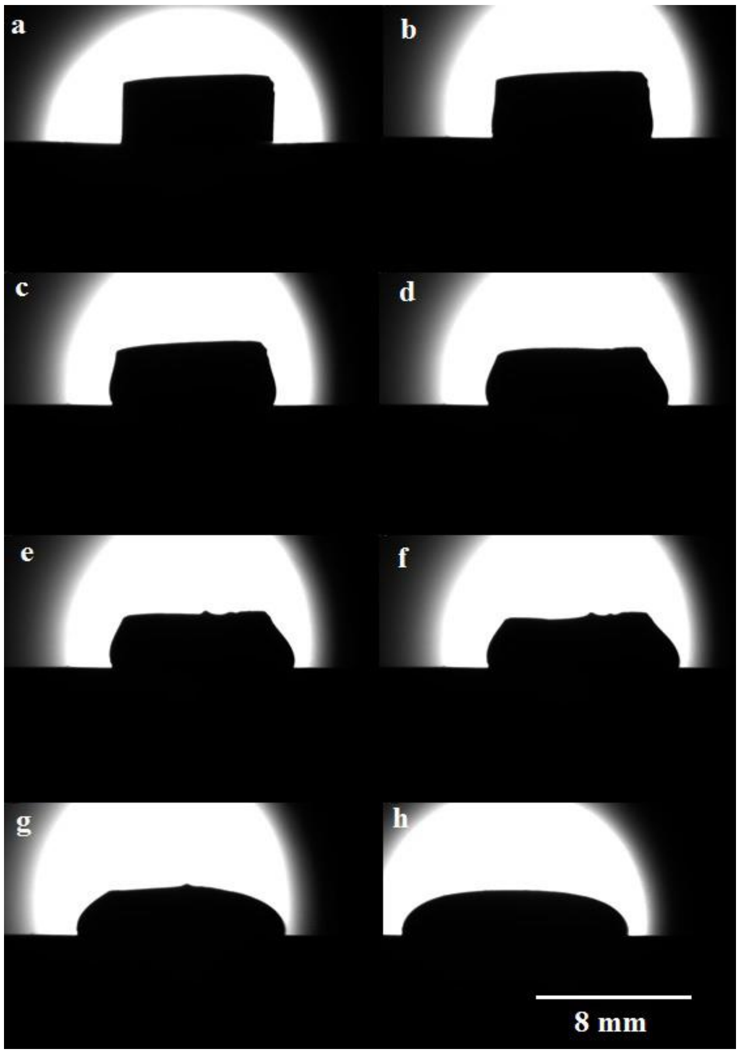
- Growth under µg
  - allows vapor growth under purely diffusive conditions, which has shown to lead to a significantly increased μ-τ product in the case of HgI_2 [1]
  - enhances the chance for detachment in the case of Bridgman growth to reduce stress in the crystal

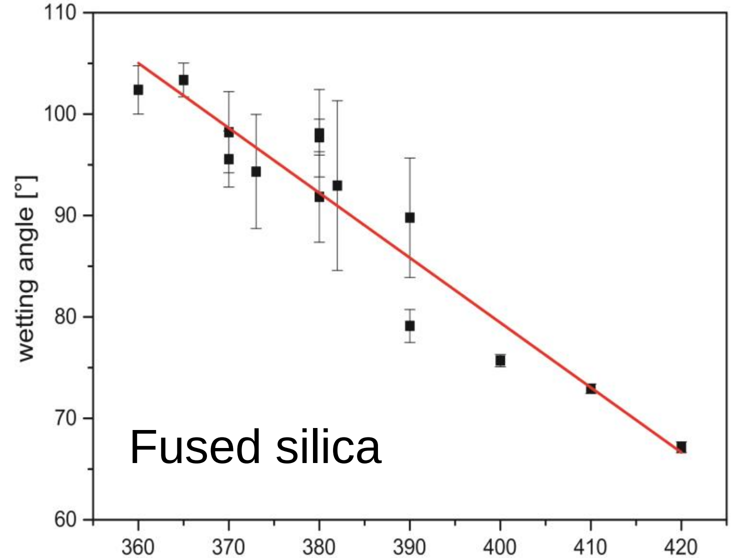
[1] L. Van den Berg and W.F. Schnepple: Mercuric iodide crystal growth in space. Nucl. Instrum. A 283 (1989), 335-338

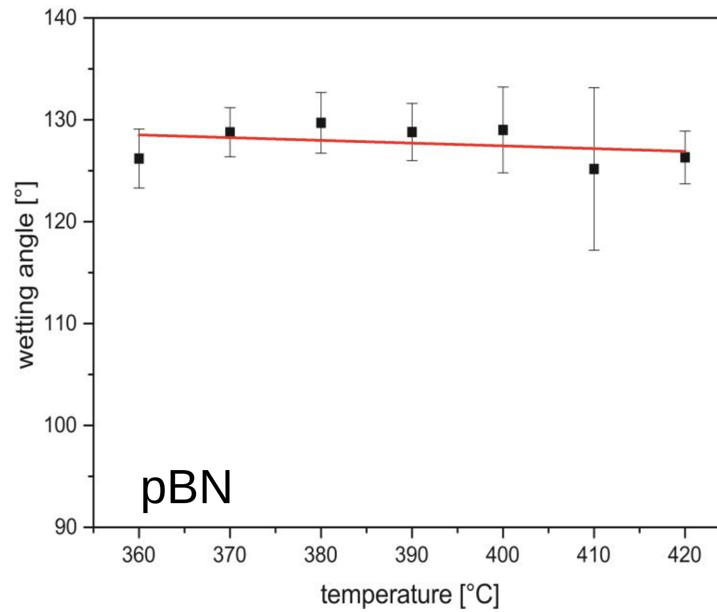
SUBSA FURNACE

- Was developed for a series of InSb experiments with a *sub*-merged baffle in the ISS MSG (microgravity science glovebox) rack.
- One heating zone, low power consumption
- Transparent gradient zone to visualize the growth interface

WETTING: SESSILE DROP TESTS



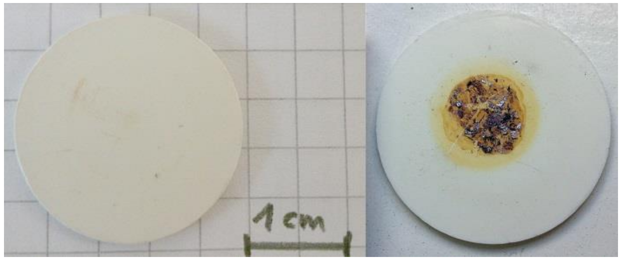




WETTING: SESSILE DROP RESULTS

- Wetting angle of InI on fused silica: 105±2.6°
  temperature coefficient: -0.64±0.06 degree/K(!), sample slides off the substrate easily

- Wetting angle of InI on pBN: 128±2.3
  temperature coefficient: -0.03±0.03 degree/K, but sample sticks and reacts with the substrate
  ($3InI + 2BN \rightleftharpoons In_3BN_2 + BI_3$)



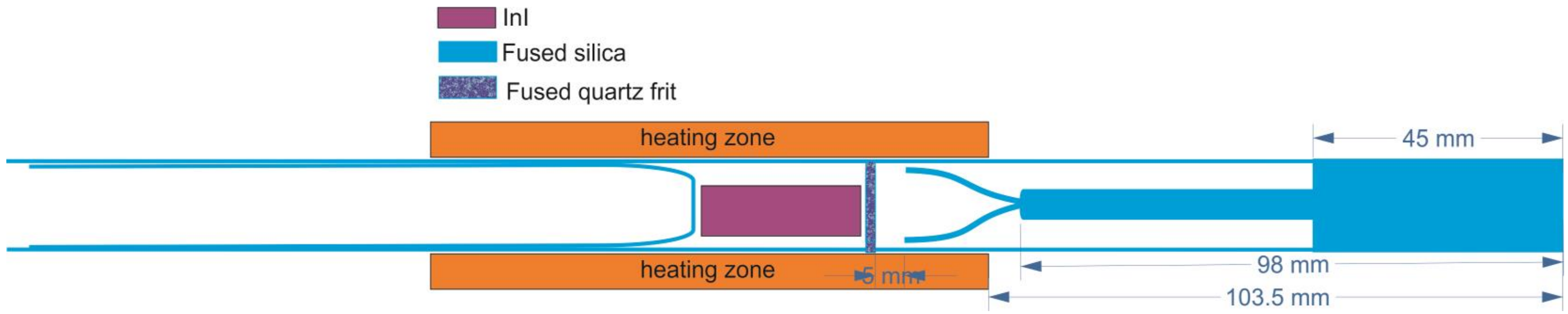
- Wetting angle of InI on Al_2O_3 ceramics: 101.6±2.1°
  temperature coefficient: -0.315±0.007 degree/K [1]

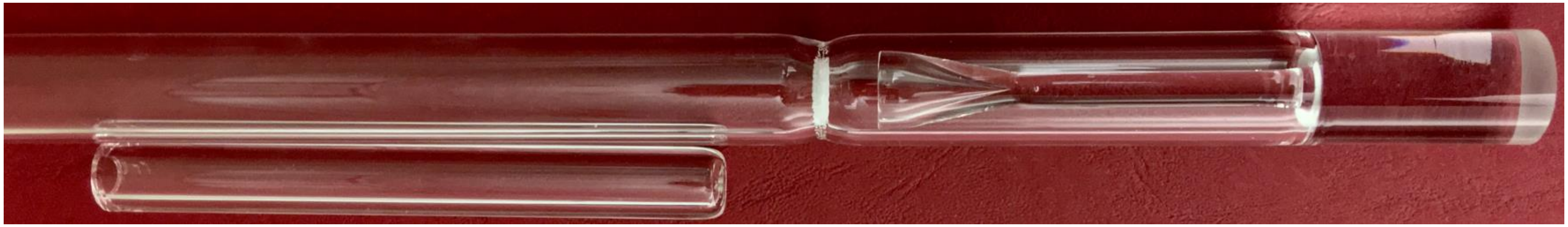
- Wetting angle of InI on carbon: 93.4±0.7°
  temperature coefficient: -0.102±0.006 degree/K [1]

[1] S.C. Fischer, Ph.D. thesis, Technical University of Aachen and FZ Jülich, 2009. In: Schriften des Forschungszentrums Jülich, Energy & Environment Vol. 44 (2009), pp. 44, 46, 73-75, 135. http://hdl.handle.net/2128/3722

VAPOR PHASE AMPOULE

Modified Markov method setup





CONCLUSIONS

- **InI has promising properties as room temperature γ-ray detector**
- **The low melting point allows Bridgman growth and CZ growth, although diameter control is difficult with the latter method**
- **Determination of the wetting angles with different crucible materials showed the highest value (128°) for pBN, but InI and pBN react, whereas fused silica (105°) does not react. Other materials better suitable for detachment have to be tested, e.g. DLC coatings.**
- **The congruent sublimation also allows vapor phase growth in comparison to melt growth**
- **The µg experiments in the “SUBSA“ furnace on the ISS are planned for 2017**

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THANK YOU FOR YOUR ATTENTION!

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